Q 52: Ultracold atoms, ions and BEC V (with A)

Time: Thursday 16:30–18:30 Location: BEBEL SR140/142

Q 52.1 Thu 16:30 BEBEL SR140/142

Beating the flux limits: An ultra-bright atom lasers based on adiabatic potentials — •Wolf von Klitzing[1], V. Bolpasi[1], N.K. Efremidis[2], M.J. Morrissey[3], P. Condylis[4], and D. Sahagun[5] — [1]FORTH- IESL — [2]Vassilika Vouton, P.O. Box 1527 — [3]Vassilika Vouton, P.O. Box 1527 — [4]FORTH- IESL , Vassilika Vouton, P.O. Box 1527 — [5]FORTH- IESL , Vassilika Vouton, P.O. Box 1527

I will present a novel, ultra-bright atom-laser and ultra-cold thermal atom beam. Using rf-radiation we strongly couple the magnetic hyperfine levels of ^{87}Rb atoms in a trapped Bose-Einstein condensate. The resulting time-dependent adiabatic potentials forms a trap, which at low rf-frequencies opens up just below the condensate and thus allows an extremely bright well-collimated atom laser to emerge. As opposed to traditional atom lasers based on weak coupling of the magnetic hyperfine levels, this technique allows us to outcouple atoms at an arbitrarily large rate. We achieve a flux of 4×10^7 atoms per second, a seven fold increase compared to the brightest atom lasers to date. Furthermore, we demonstrate by two orders of magnitude the coldest thermal atom beam (200 nK).

Q 52.2 Thu 16:45 BEBEL SR140/142

Realizing non-hermicity with ultra-cold atoms and hermitian multi-well potentials — •Manuel Kreibich, Jörg Main, and Günter Wunner — Institut für Theoretische Physik 1, Universität Stuttgart, 70550 Stuttgart, Germany

We discuss the possibility of realizing a *non-hermitian*, i. e. an *open* two-well system of ultra-cold atoms by enclosing it with additional wells that serve as particle reservoirs. With the appropriate design of the additional wells almost arbitrary currents can be induced to and from the inner wells, including the important class of $\mathcal{PT}$-symmetric currents, which support stable solutions.

We show that interaction in the mean-field limit does not destroy this property, it even allows for simple analytic expressions in the Thomas-Fermi limit. We finally discuss the implications of our results on the stability of atomic transport in optical lattices.

Q 52.3 Thu 17:00 BEBEL SR140/142

Non-equilibrium dynamics of ultra-cold atoms — •Fernando Gallego-Marcos[1], Christian Nietner[2], Gloria Platero[1], and Tobias Brandes[2] — [1]Instituto de Ciencia de Materiales, CSIC, Cantoblanco, 28049 Madrid, Spain — [2]Institut für Theoretische Physik, Technische Universität, 10623 Berlin, Germany

We study the dynamics between two ultra-cold atomic reservoirs, in the grand canonical ensemble, which initially have different temperatures and/or particle densities. These reservoirs are modeled as ideal quantum gases which are coupled to a quantum system with several discrete transition frequencies. We calculate the time dependent particle- and energy currents through the quantum system using a Born-Markov-Secular master equation approach in correspondance with Ref. [1]. Additionally, assuming a linear relation between the energy current and the change of the reservoir temperatures, we are able to model the equilibration of the reservoirs. Our numerically obtained results for fermionic particle transport are in accordance with recent experimental observations [2]. Moreover, we find a strong dependence of the equilibration on the energy structure of the quantum system. Consequently, we use a linear response approximation to analytically investigate this dependence in more detail.

References

[1] Nietner, C., Schaller, G., & Brandes, T. 2013, arXiv:1309.3488

[2] Brantut, J.-P., Grenier, C., Meineke, J., et al., Science 342, 713 (2013)

Q 52.4 Thu 17:15 BEBEL SR140/142

Cold atom sources for integrated quantum sensors — •Fedja Oručević, Anton Piccardo-Selg, Tom Barrett, Gal Aviv, Thomas Fernholz, and Peter Krüger — Midlands Ultracold Atom Research Centre, School of Physics and Astronomy, University of Nottingham, UK

The progress in trapping and manipulation of cold atoms achieved over the past decade and their intrinsic quantum nature make them ideally suited for quantum sensor applications. However, the complexity of typical cold atom setups is such that they largely remain confined to the laboratory. Recent efforts therefore focus on miniaturising and integrating different components to form truly portable devices.

At the heart of such a system is a source of cold atoms, for example based on atom chip technology. We present a new low-power design that does not require the use of external coils. With a 45°-tilted magnetic field quadrupole we trap $> 10^8$ rubidium atoms in a mirror magneto-optical trap using less than 5 W of electrical power.

Q 52.5 Thu 17:30 BEBEL SR140/142

Finite size effects stabilize inhomogeneous structures — •Florian Cartarius[1,2], Anna Minguzzi[1], and Giovanna Morigi[2] — [1]Université Grenoble 1/CNRS, Laboratoire de Physique et de Modélisation des Milieux Condensés (UMR 5493), B.P. 166, 38042 Grenoble, France — [2]Fachrichtung 7.1: Theoretische Physik, Universität des Saarlandes, D 66123 Saarbrücken, Germany

We consider classical dipolar particles in a planar geometry confined by a harmonic ring trap. Using a Basin-Hopping Monte Carlo method and analytical calculations we study the minimal energy configurations. We find that close to the linear to zigzag transition [1], the energy is minimized by inhomogeneous soliton-like configurations originating from the short-range character of dipolar interactions. We develop a long-wavelength model that takes into account the coupling between radial and axial modes and show that its solutions well account for the inhomogeneous structures. They generically emerge for power law interactions with $1/r^\alpha$, when $\alpha > 1$. The inhomogeneous structures are due to finite size effects, but are still present for systems with very large number of particles and are thus experimentally relevant.

[1] G. Birkl, S. Kassner, and H. Walther, *Nature* **357**, 310 (1992)

Q 52.6 Thu 17:45 BEBEL SR140/142

Heat transport through the isotropic Lipkin-Meshkov-Glick model — •Georg Engelhardt, Victor Manuel Bastidas, and Tobias Brandes — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

The Lipkin-Meshkov-Glick (LMG) model is a paradigmatic instance for a system exhibiting a quantum phase transition. We consider the isotropic LMG model coupled to two heat baths at different temperatures. We analytically calculate the heat current and the heat conductivity through the system using the master equation in Born-Markov-secular approximation. In the thermodynamic limit, we find that the heat conductivity vanishes in the symmetric phase while it is finite in the symmetry-broken phase.

Q 52.7 Thu 18:00 BEBEL SR140/142

Broken Integrability Trace on Stationary Correlation Properties — •Ioannis Brouzos[1], Angela Foerster[2], and Tommaso Calarco[1] — [1]Institut für Quanteninformationsverarbeitung, Universität Ulm — [2]Instituto de Fisica da UFRGS, Av. Bento Gonccalves

We show that the breaking of integrability in the fundamental one-dimensional model of bosons with contact interactions leaves its trace on the stationary correlation properties of the system. We calculate energies and correlation functions of the integrable Lieb-Liniger case where all pairs of atoms interact with the same strength, comparing the Bethe with a corresponding Jastrow ansatz which are the basic constructions of correlated wave-functions in many-body quantum physics. Then we examine the non-integrable case of different interaction strengths between each pair of atoms by means of a modified (and variationally optimized) Jastrow ansatz which we propose as a very good approximation for this case. We show that properties of the integrable state are more stable (persist if the integrability is not extremely broken) close to the infinitely strong interacting Tonks-Girardeau regime than for week interactions. All energies and correlation functions are given in terms of explicit analytical expressions which the Jastrow ansatz makes possible. We finally compare the correlations of the integrable and non-integrable case and show that appart from symmetry breaking the behavior changes dramatically, with additional and more pronounced maxima and minima (interference peaks) appearing.

Q 52.8 Thu 18:15 BEBEL SR140/142

A Thermoelectric Heat Engine with Ultracold Atoms — •Sebastian Krinner[1], Jean-Philippe Brantut[1], Charles

Grenier[1], Jakob Meineke[1], David Stadler[1], Dominik Husmann[1], Corinna Kollath[2], Tilman Esslinger[1], and Antoine Georges[3,4,5] — [1]Institute for Quantum Electronics, ETH Zürich, CH-8093 Zürich, Switzerland — [2]Universität Bonn, D-53115 Bonn, Germany — [3]Centre de Physique Théorique, École Polytechnique, CNRS, 91128 Palaiseau cedex, France — [4]Collège de France, 11 place Marcelin Berthelot, 75005 Paris, France — [5]Université de Genève, CH-1211 Genève, Switzerland

Thermoelectric effects, such as the generation of a particle current by a temperature gradient, have their origin in a reversible coupling between heat and particle flows. These effects are fundamental probes for materials and have applications to cooling and power generation. Here, we demonstrate thermoelectricity in a fermionic cold atoms channel in the ballistic and diffusive regimes, connected to two reservoirs. We show that the magnitude of the effect and the efficiency of energy conversion can be optimized by controlling the geometry or disorder strength. Our observations are in quantitative agreement with a theoretical model based on the Landauer-Büttiker formalism. Our device provides a controllable model system to explore mechanisms of energy conversion and realizes a cold atom-based heat engine.